Int. J. Chem. Sci.: 6(2), 2008, 681-687

COPPER: IT'S CONCENTRATION AND DISTRIBUTION WITH DISTANCE AND EFFECTS ON PLANTS OF CHOPRA BARI AREA, BIKANER (RAJASTHAN)

SURUCHI GUPTA and AJAY SINGH SOLANKI*

P. G. Department of Chemistry, Govt. Dungar College, BIKANER – 334003 (Raj.) INDIA

ABSTRACT

Copper is a trace element, which is required in 0.2 ppm range in irrigation water for optimum growth of plants. It plays an important role in plant structure and functions. For analysis of copper in irrigation water (industrial effluent), ten samples were collected and were analyzed on Atomic Absorption Spectrophotometer (AAS). This study revealed that concentration of copper decreases with increasing pH and distance in Chopra bari area, Bikaner. Copper, when present in toxic level, shows leaf cupping, decreased root growth and damaged cell membrane in plants while in deficient condition, young tissue chlorosis, distortion and necrosis conditions occurs in plants.

Key words: Copper, Deficiency, Toxicity, Symptoms, Distance

INTRODUCTION

Chopra bari area of Bikaner city is a vast irrigating field, which uses industrial effluent of dyes and printing units for irrigating fields. The main work of these industries is to dye the fabrics and print the clothes. For this purpose, they uses mostly mordant dyes. The mordant dyes have heavy metals, which acts as a binder between fabric and dye and also improves the fastness of colour. Many heavy metals like lead, copper, zinc, iron, manganese, aluminium and cadmium may be present as a mordant. The present study emphasizes on copper. Copper (Cu) is an essential nutrient for plant's growth but because only a small amount is needed, it is classified as a micronutrient. Copper is an important component of protein found in the enzymes that regulate the rate of many biochemical reactions in plants. Plants would not grow without the presence of these specific enzymes. Copper promotes seed production and formation and it plays an essential role in chlorophyll formation. It's deficiency and toxicity; both are lethal to plants.

* Author for correspondence; E-mail : ajay22solanki@yahoo.co.in

EXPERIMENTAL

To analyze copper, whole field area was divided into ten zones, which are at 30 meter distance to each other. Industrial effluent from these zones were collected in wide mouth plastic bottles. Prior to sampling, bottles were sequentially cleaned with detergent, tape water and double distilled water. Samples were then filtered using Whatman No. 42 filter paper and were analyzed on Atomic Absorption spectrophotometer[1-3].

RESULTS AND DISCUSSION

The concentration of copper in industrial effluents with distance is given in Table 1

Table 1. Concentration of copper in industrial effluent

Particulars	Distance (Meters)	pH	Concentration of copper (ppm)
Zone-1	-	8.55	1.5
Zone-2	30	8.95	0.97
Zone-3	60	9.31	0.44
Zone-4	90	9.75	0.41
Zone-5	120	9.85	0.29
Zone-6	150	10.23	0.28
Zone-7	180	10.36	0.23
Zone-8	210	10.56	0.2
Zone-9	240	10.83	0.17
Zone-10	270	10.96	0.14

Copper is required in 0.2 ppm range for optimum growth of plants. The perusal of Table 1 reveals that zone 1 to Zone 7 (upto distance 180 meter) are the copper toxic zone, while zone 8 (210 meter) is an adequate zone of copper, and Zone 9 and 10 (240 to 270 meter) are deficient in copper (Fig. 1)

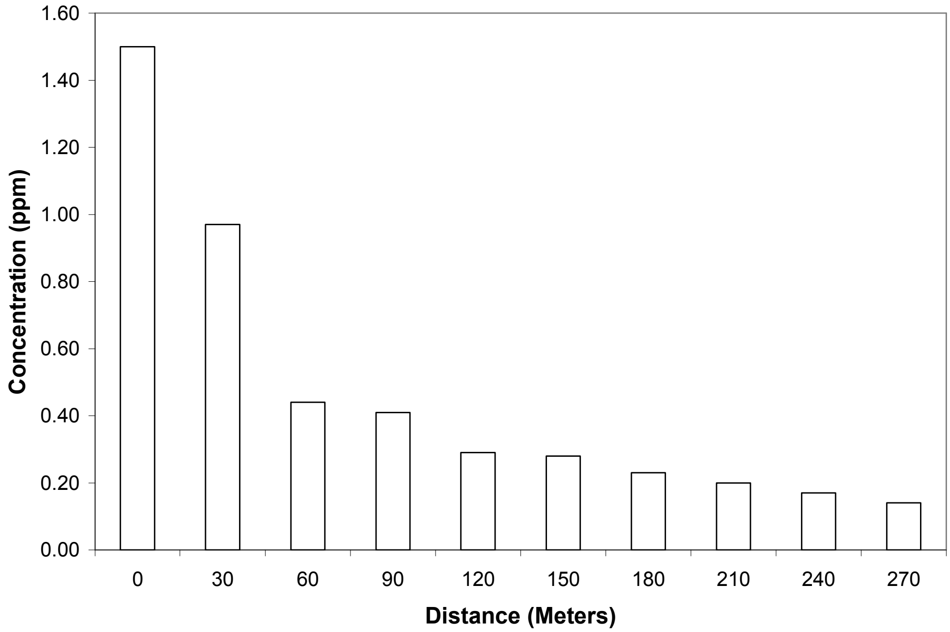

Fig. 1: Concentration of copper in industrial effluent

A study of table also reveals that the concentration of copper is decreasing, with the distance which might be due to the following reasons-

(i) If the soil is water logged, it can reduce Cu availability but while they are saturated, however after they are drained, the copper will be available again.

(ii) The factors that affect the mobility of copper in soil are total organic compounds in soil, soil dryness, its temperature cycle and water contents of the soil.

(iii) Presence of carbonate immobilizes copper by providing an adsorbing surface or by buffering the pH.

(iv) The mobility of copper in soil solutions often decreases with increasing pH and its supply to plants is correspondingly reduced because of greatly diminished solubility and increased sorption onto mineral colloid surfaces. The general effect of increasing adsorption with increasing pH is believed to be due to-

- An increased generation of pH dependent sites on the colloids,
- Reduced competition with hydrogen ions, and
- A change in the hydrolysis state of copper in solution.

(v) Soil pH, organic carbon contents, iron, manganese oxide and total metal content affect the distribution of copper between different soil fractions[4].

It is clear from the Table 1 that plants/crops grown in Zone 1 to 7 (upto a distance of 180 meter) in Chopra bari area, shows toxic effect of copper, which includes suppressed growth and slow development, because Cu^{2+} inhibits metabolic activity. Most Cu^{2+} ions are immobilized to the cell walls of roots or of mycorrhizal fungi. When the tolerance mechanisms in the root zone becomes overloaded, then Cu^{2+} is translocated by both the xylem and phloem upto the leaves. Excess Cu^{2+} may replace other metals in metalloproteins or may interact directly with SH groups of proteins. Cu^{2+} induced free radical formation may also cause protein damage. High concentration of Cu^{2+} may catalyze the formation of hydroxyl radical from O_2 and H_2O_2. This Cu^{2+} catalyzed Fenton type reaction takes place mainly in chloroplasts. The hydroxyl radical may start the peroxidation of unsaturated membranes, lipids and chlorophyll and these inhibitory mechanisms might contribute to the observed inhibition of photosynthetic electron transport by excess Cu^{2+} [5]. Copper is not readily mobile in plants and thus, result in higher copper levels in roots than in shoots and therefore, copper toxicity often results in decreased root growth and damage to root-cell membrane. Copper toxicity results in plant stunting, a bluish tint to leaf colour and leaf cupping followed by chlorosis or necrosis.

Picture showing copper deficiency in corrinder

Copper significantly increases electrolyte leakage and peroxidase activity of shoot tissues[6]. When in excess, copper interferes with the absorption of iron by plant roots; thereby, causing copper induced iron chlorosis; in excess, it also interferes with phosphorus and calcium nutrition. It also stimulate root branching on some species with naturally fibrous root system. Plants grown in higher copper concentrations have an increased number of stomata, particularly on the lower leaf surface, but stomata decreased in size. Guard cell length was reduced by about 30% on both upper and lower leaf surfaces. Excess of copper results in reduction of the volume of both; the upper and lower epidermal cell.

Table 1 shows that plant/crops planted in Zone 1 and 10 are copper deficient, The deficiency symptoms includes young tissue chlorosis, distortion and necrosis (death). The death of the growing plants often leads to excessive tillering in cereal crops and excessive branching in dicots (non-grass crops). Some vegetables show a blue-green color before advancing chlorosis. Excessive wilting, lodging and reduced disease resistance result from the weak cell wall caused by copper deficiency. Reduced seed and fruit yield is caused mainly by male sterility. Copper deficiency often causes a complete failure to set flowers. Lettuce and onions most commonly manifest visible symptoms with only a slight deficiency occurring. Carrot roots, wheat grains and onion bulb show poor pigmentation. Copper deficiencies produces shrunken heads, heads with gaps or "Frosted heads" in plants In deficient conditions, legume shows pale, erect growth habit and the leaves tends to remain cupped (as if the plant were suffering from moisture stress)[8,9]

So to manage the copper toxicity or deficiency, it is advised to adopt the following suggestions –

(i) To plant alfalfa in fields. Alfalfa is a potential source of biomaterial for the removal of heavy metal ions from water. It has been found growing in fields irrigated with water high in heavy metal concentration[10-12]. Studies have shown that alfalfa has tolerance levels to heavy metals above other plants[13-15]. This tolerance may be due to its high protein contents or the evolution of chemical functional groups in the plant cells that inhibit the toxic effect of the heavy metals because alfalfa shows itself to have a high affinity for metal ions and can be obtained with less expense and easily. It has attractive applications for the removal of metal ions from contaminated water.

(ii) Besides alfalfa, in Zone 1 to 7 (upto distance of 180 meter) plants/crops like barley, beet, broccoli, carrot, cabbage, celery, lettuce, onion pepper, rye, spinach, sudangrass, tomato, watermelon and wheat can be planted because they have high tolerance towards copper.

(iii) Zone 8 at a distance of 180 to 210 meter in Chopra bari is an adequate zone for planting vegetables/crops, because it has the required concentration of copper.

(iv) In Zone 9 and 10, which are copper deficient, the farmers are advised for foliar spray of copper fertilizers, which will meet out copper requirement of plants/crops. Excess copper application can easily damage plant roots and leaves; so proper application rates and methods are important. Soil applications of copper material can have an extremely long residual effect in the soil. Therefore, records must be kept on the total amounts applied to fields. If a foliar copper product is "basic" in nature (the pH of the copper product/carrier mixture is greater than 7.0), the potential for and severity of foliar damage can be reduced. Good responses can be obtained, if foliar applications of copper containing fungicides is applied. Some of the important copper fertilizers are copper sulphate monohydrate (Cu 35%), copper sulphate pentahydrate (Cu 25%), cupric oxide (Cu 75%), copper chlorides (Cu 17%) or copper chelates (Cu 8-13%)

Therefore, it is concluded that by applying above suggestions, growers of Chopra bari area can get rid off from copper toxicity and deficiency symptoms in their plants/crops and can increase their yields.

ACKNOWLEDGEMENT

Authors are thankful to Dr. H. K. Pandey, Head, Department of Chemistry, Govt. Dungar College and Dr. Pokarmal Rathore Project Director, Agriculture Department, Bikaner for providing necessary facilities for the above work.

REFERENCES

1. S. M. Khopkar , Environmental Pollution Analysis, New Age; New Dalhi, (2001).
2. A. K. De, Environmental Chemistry, New Age New Delhi. 5th Edition (2003).
3. Suruchi Gupta and Mridula Bhatnagar, Asian J. Chemi., **14(1)**, 344-(2002) p. 278.
4. Hossam M. Alter, Factors Affecting Mobility of Copper in Soil Water Matrics. Ph. D. Dissertation Submitted to the Virginia Polytechnic Institute and State University (2001).
5. Eija Patsikka, Eva-Mari Aro and Esa Tyystjarvi, Plant Physiol., **117**, 619 (1998).
6. Zhi-Ting Xiong, Haiwang , Environmental Toxicology, **20 (2)**, 188 (2005).

7. H. Panou-filotheou, A. M. Bosabalidis and S. Karataglis , Annals of Botany, **88,** 207 (2001).
8. M. L. Vitosh, D. D. Warncke and R. E. Lucas , Michigan State University Extension, Bulletin E-486 (1994).
9. Trace Elements Back in Focus, Ground Cover Issue 58, October/ November (2005).
10. J. L. Gardea-Torresdey, M. K. Becker, Hapak, J. M. Hosea and D. W. Darnell, Sci. Technol., **24**, 1372 (1990).
11. L. J. Cajuste, R. Carrillo, G. E. Cota and R. J. Laird, The Distribution of Heavy Metals from Waster Water in the Mexican Valley of Mezquital, Water, Air and Soil Pollution, **57-58**, 763 (1991).
12. R. Carrillo G. and L. J. Cajuste, J. Environ. Sci. Hlth., **A27**, 1771 (1992).
13. V. C. Baligar, T. A. Campbell and R. J. Wright, J. Plant Nutrition, **16**, 219 (1993).
14. J. S. Angle and R. L. Chaney, Water, Air and Soil Pollution, **57-58**, 597 (1991).
15. J. E. Rechcigl, R. B. Reneau Jr. and L. W. Zelazney, Plant Anal., **19**, 989 (1988).
16. Alfalfa Germplasm in the United States, Genetic Vulnerability Use, Improvement and Maintenance, Technical Bulletin Number 1571, USDA, November (1977).

Accepted : 13.03.2008